§5. Spatial Distribution and Velocity Distribution Function of Electrons in Annular Acceleration Region

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Anomalous electron acceleration, which forms an annular configuration on the plane perpendicular to the magnetic field, has been observed in the Hyper-I plasma. The high-energy electrons accelerated inside the annular region show an anisotropy against the magnetic field, i.e., they are intensively detected when the rotation angle of the probe surface θ is set to ± 45 degree. This anisotropy cannot be explained by usual wave-particle interactions and is one of the interesting properties of the annular electron acceleration.

In order to comprehend the detailed behavior of annular accelerated electrons, the angle distribution of electron current flowing into the DLP, in which the biased potential is varied from the plasma potential ($\phi = 0$) to –100 V, has been measured. Note that the bulk electrons are repelled when the DLP is biased sufficiently negative. The anisotropy of accelerated electrons is clearly shown in Fig. 1 as two lobes expanded at angles ± 45 degree.

Then we have attempted to evaluate the velocity distribution function of electrons in annular acceleration region by the following procedure: (i) the bulk electron temperature is determined from *I-V* characteristics without high-energy electrons, (ii) the contribution of bulk electrons for DLP current is subtracted from the electron current of *I-V* characteristics with high-energy electrons, (iii) the velocity distribution of high-energy electrons is determined by fitting a curve made by the integration of a drift Maxwellian to the curve obtained in procedure (ii). The result is shown in Fig. 2, in which the velocity distribution is well expressed by the superposition of two Maxwellian (one is drift Maxwellian). In this case, the relative density of high-energy electrons is approximately 30% of the plasma density. The temperature of high-energy electrons is 20 eV, which is three times the bulk electron temperature. The drift velocity of high-energy electrons given by the assumption of drift Maxwellian is about 2.7 times the thermal velocity of bulk electrons. Since the acceleration that predominates the thermal velocity is hardly occurred in plasmas, this result is very interesting in the viewpoint of basic plasma physics.

In conclusion, the anomalous electron acceleration observed in the Hyper-I device has many specific properties; the anisotropy against the magnetic field is the primary one. The anisotropic velocity distribution has two lobes at ± 45 degree. The meaning of this particular angle as well as the annular structure formation of the acceleration region has not been understood yet, however, usual wave-particle interactions such as Doppler shifted electron cyclotron resonance or stochastic acceleration may not give a good explanation for this phenomenon. It might be needed to consider a completely new acceleration mechanism.

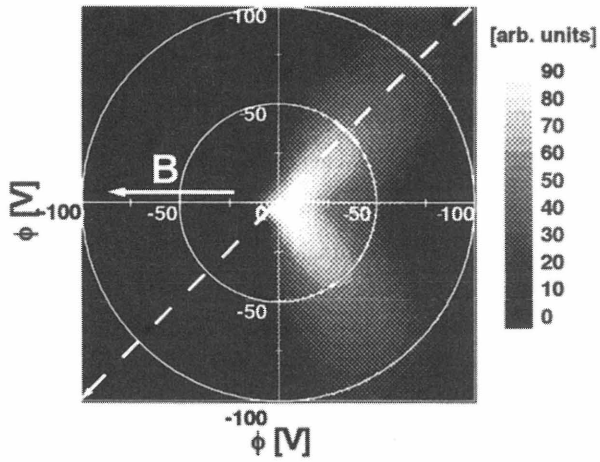

Fig. 1. Angle distribution of the electron current flowing into the DLP. The measurement has been carried out in the annular acceleration region.

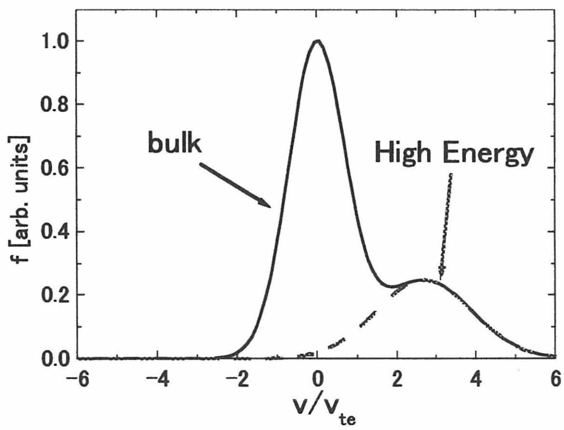

Fig. 2. One-dimensional velocity distribution of electrons, in which the angle of DLP surface is at θ = +45 degree. Axis of abscissas is normalized to the thermal velocity of bulk electrons.